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FATIGUE, WORKLOAD, AND PERSONALITY INDICES OF AIR TRAFFIC CONTROLLER STRESS DURING AN AIRCRAFT SURGE RECOVERY EXERCISE

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USAF SCHOOL OF AEROSPACE MEDICINE
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NOTICES

This final report was submitted by personnel of the Crew Performance Branch, Crew Technology Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 2729-00-19.

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The operational personnel who participated in this study were fully briefed on all procedures prior to participation in the study.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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During an aircraft surge recovery exercise, stress survey instruments were administered to 25 USAF air traffic controllers. The survey instruments consisted of sleep reports, fatigue and workload scores, and the State-Trait Personality Inventory (STPI). The STPI yields scores to measure anxiety, curiosity, and anger. Data were collected for a 4-day period during the exercise, with a maximum of 22 controllers participating on any single day. The data were collected to provide a baseline for comparison with future studies

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involving chemical warfare defense equipment. Although the controllers averaged more than 7 hours sleep per night during the exercise period, 70% felt they could have used more sleep. The average subjective fatigue level never suggested more than moderate fatigue. The average perceived workload corresponded to a "challenging but manageable" level. Average State scores for anxiety, curiosity, and anger were generally low; average Trait scores for these same emotions were below scores reported for Navy recruits and college freshmen. During the course of the exercise, significant differences were found in State anxiety scores, as the novel situation (the exercise) became a familiar routine. The major conclusion is that the surge recovery exercise, in comparison to normal duty conditions, had minimal effect on all measures for this group of controllers.

FATIGUE, WORKLOAD, AND PERSONALITY INDICES OF AIR TRAFFIC CONTROLLER STRESS DURING AN AIRCRAFT SURGE RECOVERY EXERCISE

INTRODUCTION

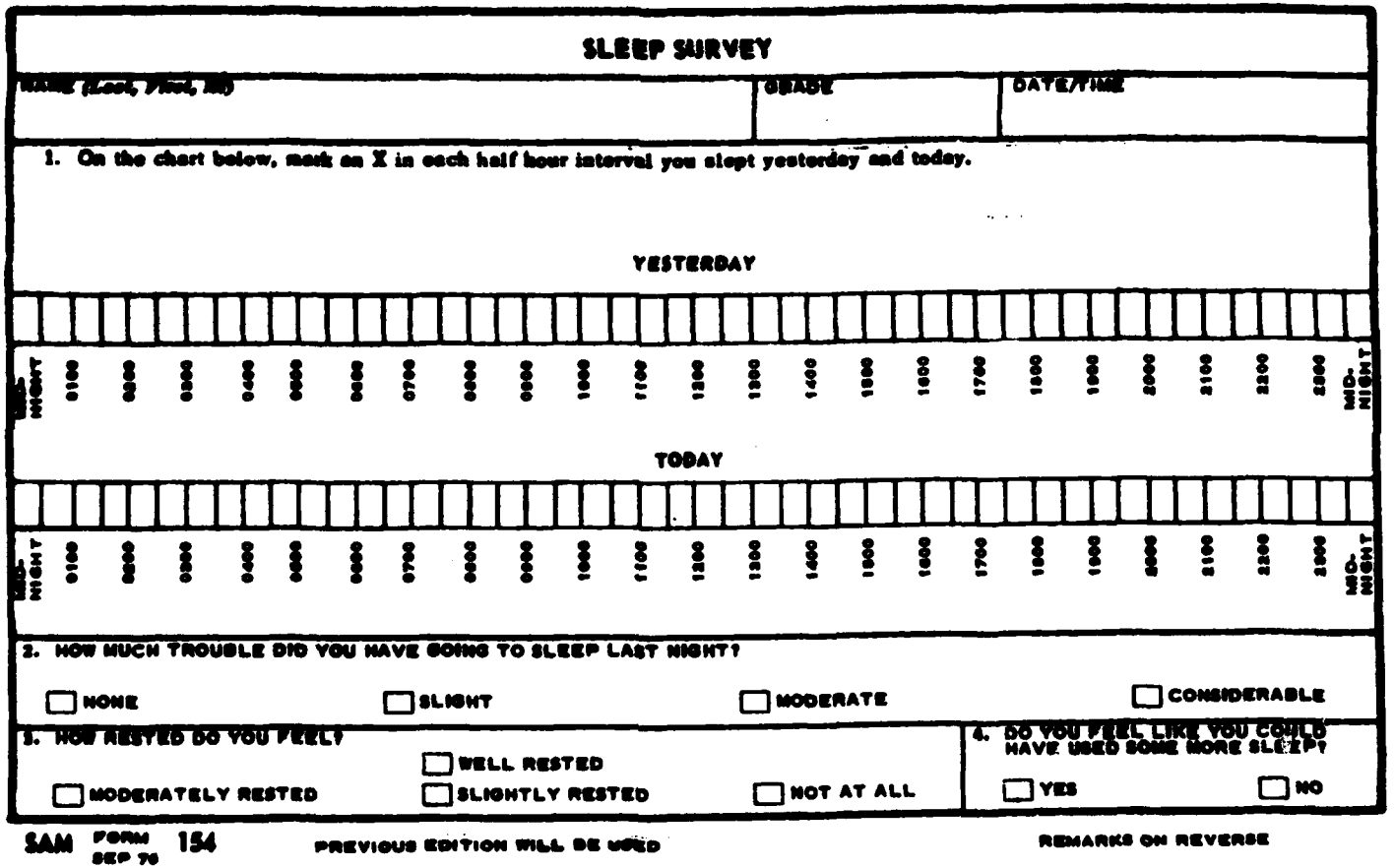
At the request of the USAF Communications Command, fatigue, workload, and personality surveys were administered to USAF air traffic controllers during 4 days of an aircraft surge recovery exercise conducted at Spangdahlem AB, Germany, 19-26 June 1981. The survey instruments were prepared by the Crew Performance Branch (VNE) of the USAF School of Aerospace Medicine (USAFSAM). The instruments were administered by task force personnel from the USAF Communications Command. The data collected will be compared with data to be collected during similar future exercises in which air traffic controllers will wear the chemical warfare defense ensemble.

METHODS

The surge recovery exercise was designed to take place during a normal duty shift. The exercise was planned to last approximately 1 hour, during which the recovery-rate goal was 72 aircraft per hour. To differentiate normal duty stress from the stresses imposed by the surge recovery exercise, the surveys were administered to the air traffic controllers four times each day: at the beginning of the duty day, before and after the exercise, and at the end of the duty day. The survey materials were prepackaged in individual envelopes for each administration period. The individual completing the material returned it to these envelopes and sealed them. The completed instruments were returned unopened to USAFSAM for scoring and analysis. Participation in the survey was voluntary, and the informed consent of each subject was obtained prior to the survey.

The first envelope for each day contained a Sleep Survey (SAM Form 154; Fig. 1), a Crew Status Survey (SAM Form 202; Fig. 2); and parts 1 and 2 of the State-Trait Personality Inventory, or STPI (1). The remaining three envelopes for each day contained the Crew Status Survey and part 1 of the STPI. The Sleep Survey, developed at USAFSAM, indicates bedtime and rising time for the previous night and also reflects the nature and adequacy of sleep. The Crew Status Survey, also developed at USAFSAM, contains two subjective 7-point scales; one for fatigue and the other for workload. Part 1 of the STPI is the State survey which assesses the individual's present subjective level of anxiety, curiosity, and anger. Part 2 of the STPI, the Trait survey, assesses the same variables but measures the long-term personality traits.

Although 25 individuals (21 males and 4 females) participated in the exercise, a maximum of 22 participated on any single day. The survey instruments were administered on 4 consecutive days during the exercise period. The planned recovery rate was not achieved on all 4 days due to various difficulties (2). On the first day of the exercise an average recovery rate of 52 aircraft per hour was achieved in a 51-minute period. Prior to the first aircraft recovery on the second day, the exercise was cancelled because of



SLEEP SURVEY

NAME (Last, First, MI) | GRADE | DATE/TIME

1. On the chart below, mark an X in each half hour interval you slept yesterday and today.

YESTERDAY

MID-NIGHT 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 MID-NIGHT

TODAY

MID-NIGHT 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 MID-NIGHT

2. HOW MUCH TROUBLE DID YOU HAVE GOING TO SLEEP LAST NIGHT?

☐ NONE ☐ SLIGHT ☐ MODERATE ☐ CONSIDERABLE

3. HOW RESTED DO YOU FEEL?

☐ WELL RESTED ☐ MODERATELY RESTED ☐ SLIGHTLY RESTED ☐ NOT AT ALL

4. DO YOU FEEL LIKE YOU COULD HAVE USED SOME MORE SLEEP?

☐ YES ☐ NO

SAM FORM SEP 76 154 PREVIOUS EDITION WILL BE USED REMARKS ON REVERSE

Figure 1. SAM Form 154: Sleep Survey.

NAME	DATE AND TIME

SUBJECTIVE FATIGUE

(Circle the number of the statement which describes how you feel RIGHT NOW.)

1	Fully Alert; Wide Awake; Extremely Peppy
2	Very Lively; Responsive, But Not At Peak
3	Okay; Somewhat Fresh
4	A Little Tired; Less Than Fresh
5	Moderately Tired; Let Down
6	Extremely Tired; Very Difficult to Concentrate
7	Completely Exhausted; Unable to Function Effectively; Ready to Drop

COMMENTS

WORKLOAD ESTIMATE

(Circle the number of the statement which best describes the MAXIMUM workload you experienced during the past work period. Put an X over the number of the statement which best describes the AVERAGE workload you experienced during the past work period.)

1	Nothing to do; No System Demands
2	Little to do; Minimum System Demands
3	Active Involvement Required, But Easy to Keep Up
4	Challenging, But Manageable
5	Extremely Busy; Barely Able to Keep Up
6	Too Much to do; Overloaded; Postponing Some Tasks
7	Unmanageable; Potentially Dangerous; Unacceptable

COMMENTS

PREVIOUS EDITION WILL BE USED

SAM FORM 202 APR 81 CREW STATUS SURVEY

Figure 2. SAM Form 202: Crew Status Survey.

thunderstorms. On the third day 28 aircraft were recovered in 62 minutes, double the average peacetime recovery rate. During the fourth day 35 aircraft were recovered in 42 minutes, for an average of 50 aircraft per hour.

Surveys were completed four times each day on days 1 and 3, as planned. On day 2, cancellation of the exercise resulted in the surveys being completed only three times. On day 4, the surveys were completed only twice, before and after the duty day. All surveys were returned to USAFSAM where they were scored and analyzed using the BMDP statistical computer package (3).

RESULTS

Sleep Survey

The mean bedtimes, rising times, and hours slept the previous night are shown in Table 1. As a group, the air traffic controllers averaged more than 7 hours sleep each night during the exercise. The individual minimum sleep was 4 hours and the maximum was 13.5 hours; both extremes were for the night preceding the first exercise day. Mean bedtimes were similar for days 1, 2, and 4; mean rising times were similar for days 1, 3, and 4. The mean bedtime was almost an hour earlier on the night preceding day 3 in comparison to the other three nights. The mean rising time on day 2 was approximately 1 hour earlier than the rising time on the other days.

TABLE 1. MEAN BEDTIMES, RISING TIMES, AND HOURS SLEPT BY AIR TRAFFIC CONTROLLERS DURING SURGE RECOVERY EXERCISE

	N	$\bar{X}$	SD	Minimum	Maximum
Bedtime					
Day 1	22	2240	-	1530	0130
Day 2	12	2235	-	2000	0130
Day 3	19	2146	-	1900	0030
Day 4	11	2241	-	1930	0030
Rising time					
Day 1	22	0552	-	0400	0900
Day 2	12	0650	-	0400	1130
Day 3	19	0540	-	0400	0700
Day 4	11	0552	-	0500	0800
Hours slept					
Day 1	22	7.2	1.9	4.0	13.5
Day 2	12	8.25	1.6	6.5	11.5
Day 3	19	7.9	2.2	6.0	10.5
Day 4	11	7.18	1.1	6.0	9.5

The responses to the questions on the Sleep Survey are shown in Table 2. The results were calculated as percentages of the total number of individuals responding to the various choices for each question. Ninety percent or more of the controllers had only slight or no trouble going to sleep. Only one person (on day 3) had considerable trouble going to sleep. At least 65% of the controllers felt moderately or well rested on all four mornings of the exercise. However, more than 70% felt like they could have used more sleep throughout the exercise.

TABLE 2. QUALITY-OF-SLEEP SURVEY OF AIR TRAFFIC CONTROLLERS DURING SURGE RECOVERY EXERCISE

How much trouble did you have going to sleep last night?

	N	None	Slight	Moderate	Considerable
Day 1	22	50%	41%	9%	0
Day 2	12	42%	58%	0	0
Day 3	19	37%	53%	5%	5%
Day 4	11	73%	27%	0	0

How rested do you feel?

	N	Well rested	Moderately rested	Slightly rested	Not at all
Day 1	22	14%	63%	23%	0
Day 2	12	42%	25%	33%	0
Day 3	20	30%	35%	25%	10%
Day 4	11	36%	36%	28%	0

Do you feel like you could have used some more sleep?

	N	Yes	No
Day 1	22	82%	18%
Day 2	11	73%	27%
Day 3	19	74%	26%
Day 4	11	82%	18%

Subjective Fatigue

The mean subjective fatigue levels for all reporting periods exceeded 2.9 only once during the exercise (Table 3). The highest mean score (3.5) occurred at the end of the first duty day--the first exercise period. The lowest mean score (1.9), corresponding to a minimal fatigue level, occurred at the end of the last duty day--the final exercise period. The mean fatigue scores throughout the exercise never suggested even moderate fatigue. The individual subjective fatigue scores, however, had a considerable range: from a low of 1 to a high of 6. Three individuals reported scores of 6, corresponding to being extremely tired and finding it very difficult to concentrate. These high scores occurred at the end of the duty day on days 1 and 3 and at the end of the exercise on day 3. Most the controllers reported fatigue scores corresponding to being a "little tired."

TABLE 3. MEAN SUBJECTIVE FATIGUE SCORES OF AIR TRAFFIC CONTROLLERS DURING SURGE RECOVERY EXERCISE

	N	$\bar{X}$	SD	Minimum	Maximum
Day 1					
Beginning of duty day	22	2.7	0.9	2	5
Beginning of exercise	18	2.4	1.2	1	5
End of exercise	20	2.1	0.9	1	4
End of duty day	17	3.5	1.4	1	6
Day 2					
Beginning of duty day	12	2.4	1.2	1	5
Beginning of exercise	11	2.8	1.5	1	5
End of exercise	--	---	---	-	-
End of duty day	16	2.3	1.1	1	4
Day 3					
Beginning of duty day	20	2.9	1.3	1	5
Beginning of exercise	11	2.5	1.2	1	5
End of exercise	16	2.5	1.2	1	6
End of duty day	14	2.6	1.4	1	6
Day 4					
Beginning of duty day	11	2.6	0.8	1	4
Beginning of exercise	--	---	---	-	-
End of exercise	--	---	---	-	-
End of duty day	11	1.9	0.9	1	4

Workload

The mean perceived workload levels stayed below 4 throughout the exercise (Table 4). A workload level of 4 on the Crew Status Survey is described as "challenging, but manageable." The largest mean workload scores (3.6, 3.5) occurred at the end of duty on days 2 and 4. As with subjective fatigue, the individual workload estimates had a considerable range--from a low of 1 to a high of 6. Two individuals recorded scores of 6 at the end of duty on day 2. This workload level corresponds to "too much to do; overloaded; postponing some tasks." Workload estimates of 5 occurred only three times during the exercise and were reported by three different individuals. This workload score, described as "extremely busy; barely able to keep up," was reported at the beginning of the exercise on day 1, beginning of duty on day 2, and at the end of duty on day 4. Most controllers reported workload estimates at the "challenging, but manageable" level or below.

TABLE 4. MEAN WORKLOAD SCORES OF AIR TRAFFIC CONTROLLERS DURING SURGE RECOVERY EXERCISE

	N	$\bar{X}$	SD	Minimum	Maximum
Day 1					
Beginning of duty day	22	2.9	0.9	1	4
Beginning of exercise	18	2.3	1.2	1	5
End of exercise	20	2.5	1.3	1	4
End of duty day	17	2.5	1.1	1	4
Day 2					
Beginning of duty day	13	2.7	1.1	1	5
Beginning of exercise	11	3.0	1.0	1	4
End of exercise	--	---	---	-	-
End of duty day	16	3.6	1.2	2	6
Day 3					
Beginning of duty day	19	2.6	1.1	1	4
Beginning of exercise	10	1.8	0.9	1	3
End of exercise	16	2.1	1.0	1	4
End of duty day	14	2.6	0.9	1	4
Day 4					
Beginning of duty day	11	2.1	0.9	1	4
Beginning of exercise	--	---	---	-	-
End of exercise	--	---	---	-	-
End of duty day	11	3.5	0.9	2	5

State-Trait Personality Inventory

Results of the Trait portion of the STPI, which asks the individual to rate how he or she generally feels in response to a series of descriptive phrases, are shown in Table 5. The scores for the STPI subscales measuring anxiety, curiosity, and anger may range from 10, indicative of the lowest level, to 40, the highest level.

The mean scores for Trait anxiety and Trait anger are relatively low, indicating generally low levels for these emotions in this sample of air traffic controllers. The mean score for Trait curiosity indicates relatively high levels of curiosity. For purposes of comparison, Table 5 also shows the mean scores of college students and Navy recruits for the Trait portion of the STPI (1). All scores are lower for the air traffic controllers.

TABLE 5. MEAN TRAIT SCORES FROM STATE-TRAIT PERSONALITY INVENTORY

		Anxiety		Curiosity		Anger	
	N	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Air traffic controllers*	22	14.3	2.9	27.7	6.7	16.4	3.6
(minimum score)		(11)		(20)		(11)	
(maximum score)		(21)		(40)		(24)	
College students**	95	17.9	4.5	29.7	5.1	18.7	5.1
Navy recruits**	98	19.2	5.1	28.7	5.1	20.9	5.7

*Prior to surge recovery exercise.
**Scores from Spielberger (1).

Results for the State portion of the STPI are shown in Table 6. The highest mean State anxiety score occurred at the beginning of the exercise on day 1; the lowest, at the beginning of duty on day 4. The mean State curiosity scores were highest at the beginning of duty on day 1 and end of duty on day 4; the lowest, at the end of duty on day 1. Mean State anger scores were very low throughout the exercise days; the highest occurred at the beginning of the exercise on day 1.

A two-tailed t-test was used to test for significant differences in means for the State STPI scores. While all of the mean anxiety scores suggest relatively low levels of anxiety, significant differences were found during the exercise. Mean anxiety increased significantly ($P<0.05$) between beginning of duty and beginning of the exercise on day 1. The mean anxiety scores also showed a significant decrease ($P<0.01$) between the beginning and end of the exercise on day 1. On day 2 a significant increase ($P<0.05$) in anxiety occurred between the beginning of duty and beginning of the exercise. On day 3, mean anxiety decreased significantly ($P<0.05$) from the beginning to the end of the exercise, and then increased significantly by the end of the duty day. On day 4, anxiety increased significantly ($P<0.05$) between the beginning and the end of the duty day.

The only significant change ($P<0.05$) in mean curiosity was a decrease that occurred between the end of the exercise and end of duty on day 1. The mean anger scores also show only one significant change ($P<0.05$)--an increase on day 2 between the beginning of duty and the beginning of the exercise. However, since the minimum possible score is 10 and the significant change in mean anger score is from 10.5 to 12.5, the actual change in State anger is negligible.

Tests for significant differences in means for fatigue and workload were not attempted: the mean fatigue scores did not suggest even moderate levels of fatigue and the mean workload scores did not exceed the "manageable" level.

TABLE 6. MEAN STATE SCORES (STATE-TRAIT PERSONALITY INVENTORY) FOR AIR TRAFFIC CONTROLLERS DURING SURGE RECOVERY EXERCISE

		Anxiety		Curiosity		Anger	
	N	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Day 1							
Beginning of duty day	22	16.3	4.2	26.3	7.5	11.8	4.0
Beginning of exercise	18	18.1*	4.5	23.4	7.8	13.2	5.5
End of exercise	20	14.9**	3.6	25.6	5.8	12.7	4.9
End of duty day	17	16.2	3.9	21.1*	5.4	12.8	5.4
Day 2							
Beginning of duty day	13	13.8	3.1	23.1	5.4	10.5	1.7
Beginning of exercise	11	15.6*	3.6	24.0	4.0	12.5*	3.9
End of exercise	--	----	---	----	---	----	---
End of duty day	16	17.2	4.1	24.4	5.2	11.7	3.1
Day 3							
Beginning of duty day	20	15.1	3.4	23.1	4.6	10.3	0.8
Beginning of exercise	11	15.5	4.6	23.2	5.0	10.6	1.5
End of exercise	16	13.6*	3.0	22.7	3.8	10.6	1.6
End of duty day	14	15.1*	3.4	23.9	6.2	10.3	0.6
Day 4							
Beginning of duty day	11	12.4	2.8	24.5	5.2	10.0	0.0
Beginning of exercise	--	----	---	----	---	----	---
End of exercise	--	----	---	----	---	----	---
End of duty day	11	14.4*	3.4	26.6	3.6	10.6	2.1

* Difference between this mean and the one above is significantly different at the $P<0.05$ level.

** Difference between this mean and the one above is significantly different at the $P<0.01$ level.

DISCUSSION

The mean hours of sleep for each night preceding the exercise days indicate that the controllers generally obtained an adequate amount of sleep; however, responses to the question about the need for more sleep indicate otherwise. More than 70% of the controllers felt they could have used more sleep on all 4 days. It is interesting to note that the individuals with the greatest (13.5 hours) and the least (4.0 hours) amount of sleep for day 1 both felt they did not need more. In contrast, all of the controllers with 7 to 9 hours of sleep on the night preceding day 1 felt they could have used more. The relationship between hours of sleep and feelings of adequate sleep is highly subjective and variable. Based on these results, air traffic controllers should be advised to obtain nightly sleep consistent with their own feelings of being rested.

The mean subjective fatigue scores and the mean workload scores suggest that neither fatigue nor workload were excessive during normal duty or exercise conditions. Three individuals experienced fatigue levels corresponding to being extremely tired and finding it difficult to concentrate, but most of the controllers did not reach levels of even moderate fatigue. Five individuals reported workloads to be extremely busy or greater; only one of these reports occurred during an exercise period. The fatigue and workload results indicate that most of the controllers did not judge the surge recovery exercise to be more stressful than normal duty.

Although this study found no substantial changes in mean workload or fatigue for the exercise periods, the planned recovery rate and length of the exercise period were not attained. The lower recovery rates, with recovery occurring in waves, and the short time periods were inadequate to stress the controllers. Also, the novelty and challenge of the exercise itself may have actually contributed to a reduction in subjective fatigue and workload.

The STPI Trait scores, when compared to scores of college students and Navy recruits, show that this group of air traffic controllers generally have less anxiety and anger and slightly less curiosity. The mean State anxiety, curiosity, and anger scores show that the controllers maintained a generally low level of stress throughout the exercise. The increased anxiety scores at the beginning of duty and beginning of the exercise on day 1 would be anticipated due to the introduction of a novel situation. By the end of duty on day 4, the mean State anxiety scores are comparable to the mean Trait anxiety scores.

Although the mean State anxiety scores are relatively low, significant differences in these scores were found as a result of the exercise. The results suggest a pattern of adaptation in anxiety during the course of the exercise. The results also suggest that the STPI is sensitive to subtle changes in State anxiety. Mean anxiety at the beginning of duty is highest on day 1 and lowest on day 4. For days 1 and 2, anxiety levels at the beginning of the exercise significantly increase in comparison to levels at the beginning of duty. The subsequent decrease in mean anxiety at the end of the exercise on days 1 and 3 indicates that the exercise was the source of the anxiety. Unfortunately, comparable data for day 2 is not available because

the exercise was cancelled due to thunderstorms. The bad weather for the remainder of day 2 most likely contributed to the high mean anxiety score at the end of the duty day.

The exercise cancellation and weather may also be the source of the higher anxiety at the beginning of duty on day 3. The trend suggested by these data is a tendency for anxiety to increase from the beginning of the duty day to the beginning of the exercise, decrease at the end of the exercise, and at the end of the duty day to increase to the beginning-of-duty-day levels. Also, the mean anxiety levels tend to decrease over the course of the exercise period as the new situation (e.g., the exercise) becomes familiar.

CONCLUSIONS

On this group of air traffic controllers, the effect of the surge recovery exercises was minimal for all measures in comparison to normal duty conditions. From a behavioral aspect, the short exercise periods, lack of sustained recovery operations, and the novelty and challenge of the exercise combined to diminish any deleterious workload or fatigue effect on most of the controllers.

Although the data were incomplete, the anxiety scores suggest an adaptation trend. These scores increased at the beginning of the exercise, decreased at the end of the exercise, and at the end of the day increased to at least the beginning-of-duty-day levels. Over the course of the exercise, as the novel conditions generated by the exercise became routine, the mean anxiety scores decreased.

The members of the task force who administered the survey did an excellent job; however, in future exercises a USAFSAM scientist should be included to collect performance and behavioral data. It is imperative that the task scientist responsible for data analysis and interpretation have firsthand knowledge of the environmental conditions and crew interactions during the exercise.

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